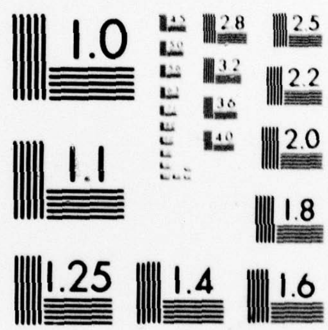
AD-A072 186 NAVY UNDERWATER SOUND LAB NEW LONDON CT F/G 20/1
HYDRODYNAMIC SOURCES FOR UNDERWATER SOUND.(U)
APR 57 R H MELLEN
UNCLASSIFIED USL-TM-1105-9-57 NL

1 OF 1

AD A072186

END
DATE FILMED
9-79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

466
M. Bishop

LEVEL II

Copy 25 of Copies

USL Problem
No. D1F6

U. S. Navy Underwater Sound Laboratory
Fort Trumbull, New London, Connecticut

HYDRODYNAMIC SOURCES FOR UNDERWATER SOUND

by

Robert H. Mellen

USL Technical Memorandum No. 1105-9-57

USL-TM-

26 April 1957

8p.

18674 3A

INTRODUCTION

The Research Division has undertaken the problem of investigating the feasibility of using hydraulic powered generators for low frequency acoustic sources under project D1F6. The purpose of this memorandum is to review the background and development of ideas in connection with this problem and to outline proposed future work.

Although the idea of using hydraulic power for acoustics is quite old, very little significant progress was made in this field before the work of Dr. J. V. Bouyoucos (reference (a)) of the Acoustic Research Laboratory, Harvard University. He succeeded in developing an efficient self-excited hydrodynamic oscillator, and was also successful in applying theoretical techniques similar to those used for electronic circuits to analyze the oscillator's behavior. The chief advantage of these hydrodynamic systems for underwater sound lies in their simplicity, small size, and economy of construction and operation. It is expected that for power above 100 kilowatts (steady state), the size and cost of an electronic system would be considerably greater, perhaps more than twice that for a hydrodynamic system of the same power. Another advantage lies in the fact that the acoustic power is developed within a liquid under high static pressure and is readily radiated into the water medium without a complicated transducer.

A further extension of the hydrodynamic source lies in the use of electro-hydraulic servo-mechanisms. In these systems the hydraulic power is converted into acoustic power which can be used to drive a radiator as above, but here the output is controlled by electric signals which actuate the valve mechanisms. This permits accurate control of frequency and even makes it possible to use signals of arbitrary wave form.

78 08 07 389

Encl (1) to USN/USL ltr ser 1430-279 of 6-7-57

254 200

DISCLAIMER NOTICE

/

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. 1105-9-57	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HYDRODYNAMIC SOURCES FOR UNDERWATER SOUND		5. TYPE OF REPORT & PERIOD COVERED Tech memo
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Mellen, Robert H.		8. CONTRACT OR GRANT NUMBER(s) N6-ONR-~~27135~~
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Underwater Systems Center New London, CT		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research, Code 220 800 North Quincy St. Arlington, VA 22217		12. REPORT DATE 26 APR 57
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

USL Tech. Memo.
No. 1105-9-57

THE HYDRODYNAMIC OSCILLATOR

The Buoyoucos hydrodynamic oscillator system is illustrated in Figure 1. Hydraulic energy is produced by the electric motor and pump assembly. The liquid flows into the oscillator which converts the hydrodynamic power into compressional waves or acoustic power in the cavities at either end. This conversion is accomplished by an oscillatory valve action which causes the liquid to flow through either cavity alternately. Regenerative feedback is inherent in the valve system and coupled cavities. The resonant frequency of oscillation depends on the valve mass and compliance of the liquid-filled chambers and is calculated by conventional acoustical methods.

The acoustic power may be taken from either or both cavities and radiated or dissipated in a dummy load for test purposes. The ratio of the acoustic power delivered to the load to that delivered to the input of the Bouyoucos oscillator gives the hydroacoustic efficiency which may be as much as 60%. The mode of operation is called Class B in analogy with electronic amplifiers where the plate current flows for one half cycle alternately on either side of a push-pull circuit and is cut off during the other half cycle. In the hydrodynamic oscillator the static pressure is sinusoidally modulated approximately 100% for maximum power output without cavitation. Thus far the source pressure has been limited to 100 psi (gauge) with approximately 5 gallon/minute flow. The cavity peak-to-peak pressure is then roughly 7 atmospheres and the power output approximately 100 watts. Experiments with one model of the Bouyoucos oscillator are now in progress Preliminary measurements show rough agreement with those of Bouyoucos; however, further work is needed to refine the measurement techniques. It is expected that the model now under investigation can be pushed to 1 kilowatt input by simply increasing the pump system from the present 2 HP to 5 HP. For greater power the oscillator must be redesigned.

One of the great disadvantages of the self-excited oscillator is that the frequency cannot be controlled precisely and depends somewhat on load conditions. For some applications it will be desirable to achieve exact frequency control by external means. This suggests that instead of a self-excited oscillator, one should consider the possibilities of a hydrodynamic amplifier employing a similar principle of operation.

HYDRAULIC AMPLIFIER

Considerable progress has been made in this relatively new field over the past five years in application to industrial servo-mechanisms. It appears that some of these techniques can be taken over into the acoustic field with little or no modification.

One of the most promising developments in this respect is the hydraulic shake table exciter manufactured by the M. B. Manufacturing Company of New Haven. This device, designed for vibration testing, is powered by a 3000 psi hydraulic source and is capable of a frequency range up to approximately 100 cps. The schematic is shown in Figure 2. Electrical signals are fed to the servo-control valve which actuates successive amplifiers, and finally a piston to which the test sample is fastened. Forces up to 15,000 pounds have been produced with a mass load of approximately 100 pounds. At present the units operate at approximately 25 g.p.m., and the input power is limited to approximately 30 kw. The conversion efficiency is estimated to be in the vicinity of 50%, although no exact figures are available at present. The hydraulic supply system is capable of roughly 100 kw. output, which if converted to acoustic power would yield in the neighborhood of 50 kw. These relatively large powers are handled with remarkable ease with uncomplicated and compact equipment. Converting such a system for an underwater acoustic source seems very attractive even though the frequency may be somewhat lower than might be desired. Discussions with the M. B. representatives indicate that they are willing to undertake a contract to provide a system with hydraulic pump and driver capable of converting roughly 100 kilowatts of hydraulic power into a dissipative load with reasonable efficiency. Further discussions are necessary before the specifications of the system can be made and a project proposal made. It is hoped that the consulting services of Dr. Bouyoucos will be available in drawing up these specifications, as well as in subsequent prosecution of the project.

RADIATION

One of the major problems that must be solved is the radiation problem. Once the acoustic energy is generated it must be conducted to the desired region where it is to be radiated into the surrounding medium. The conduction problem is easily solved by conventional waveguide techniques, the wave being confined to liquid-filled, thick-wall tubes. Radiation can probably be accomplished by feeding the energy to compliant tube elements with suitable matching sections. There are many possible variations in the radiation system but a simple monopole radiator, as described, will suffice to demonstrate the practicability of the method, in particular for the high power densities involved. Directivity can be obtained by arrangement of the radiating elements to form a beam, using much the same methods as for radio antennae. Many other possible radiation systems are possible but will not be discussed here.

SUMMARY

Work on the Bouyoucos oscillator is continuing with the aim of gaining experience in the design, operation, and measurement techniques.

The power limitation of the present oscillator will be tested with a new 5 H.P. pump system.

It is proposed that experiments with electro-hydraulic amplifiers be undertaken. This work will be facilitated by procuring from the M. B. Manufacturing Company a high power hydraulic system and exciter unit similar to the one now used for vibration testing. It will then be possible to investigate immediately the problems of generating and radiating high power, restricting interest temporarily to the frequency range around 100 cps. Further consideration should then also be given to the design of high power amplifier systems capable of frequencies up to 1000 cps. In the latter problem, experience with the Buoyoucos oscillator will be valuable.

Robert H. Mellen
ROBERT H. MELLEN
Electronic Scientist

LIST OF REFERENCES

(a) J. V. Bouyoucos, "Self-Excited Hydrodynamic Oscillators," Acoustics Research Laboratory, Harvard University, Technical Memorandum No. 36.

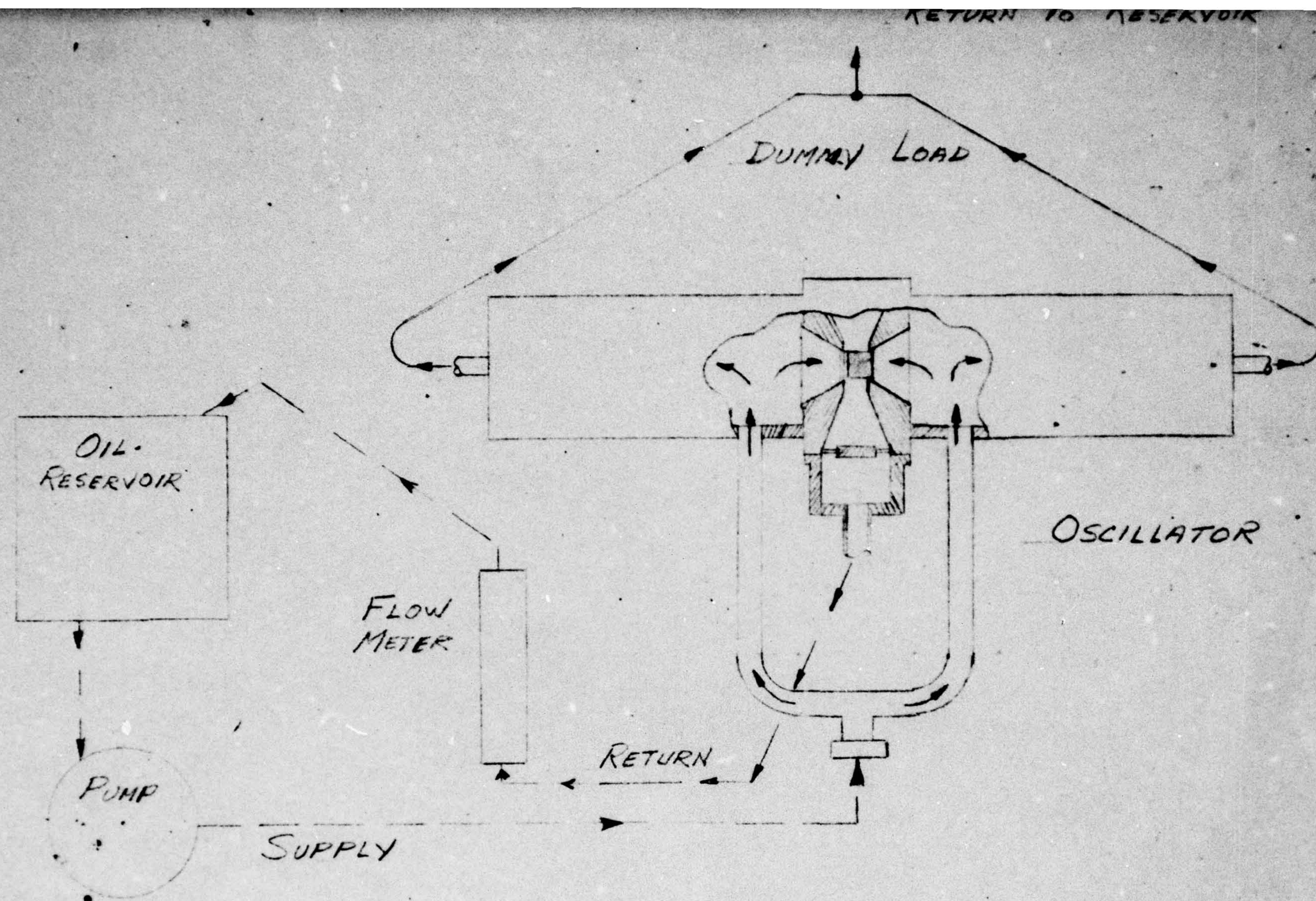
DISTRIBUTION LIST

Internal

USL Code 100
900
905
1100
1100 A
1105
1110
1170
1410
1463 (5)
K. L. Moothart
R. Berman
O. P. Dickson

External

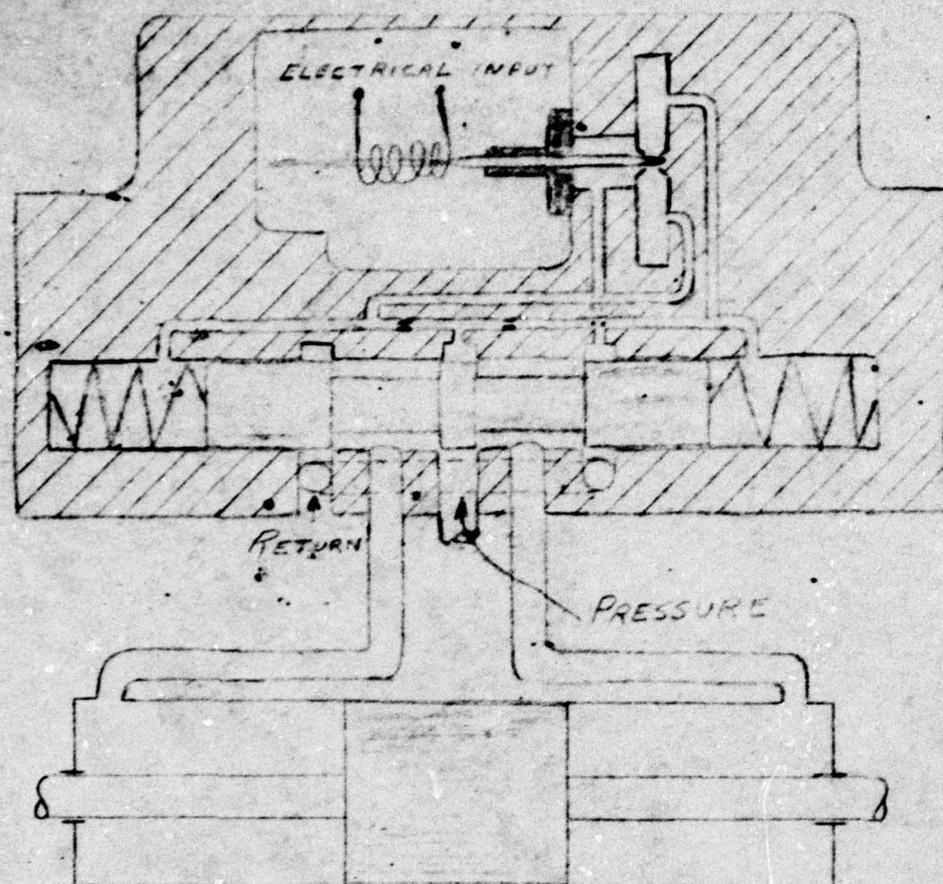
BUSHIPS (Code 845)
ONR (Code 411)
ONR (Code 466)
Acoustics Research Lab., Harvard University,
Attention Dr. J. V. Bouyoucos (via ONR, Boston)



BLOCK DIAGRAM

BOUYOUCOS HYDRODYNAMIC OSCILLATOR

FIG. 1



BLOCK DIAGRAM

HYDRAULIC AMPLIFIER

FIG. 2